Properties of maximum radar reflectivity profiles in convection reaching above tropopause

Nana Liu[1], Chuntao Liu[1], and Edward J. Zipser[2]
1. Texas A&M University – Corpus Christi 2. University of Utah

Objects:

- What are the characteristics of overshooting convection over different regions?
- Is TRMM and GPM consistent in the properties of maximum Ku reflectivity profiles in overshooting convection?

Data and methods:

- The Precipitation Features (PFs) are udefined by grouping contiguous precipitating pixels indicated by Ku radar with two-year (201403-201602) GPM observations.
- The Overshooting PFs (OPFs) are defined with maximum 20 dBZ echo top height above the lapse rate tropopause (WMO definition), which is calculated using the ERA-Interim reanalysis data (6 hourly with 0.75° horizontal resolution at 37 pressure levels).
- Profiles of maximum reflectivity and areas with reflectivity greater or equal to 20, 30, 40 dBZ in each OPF are calculated. Then, 10%, median, and 90% of these profiles are analyzed over different regions.
- For comparison, 16 years of TRMM OPFs are analyzed and compared in the tropics (20°N-20°S) and sbtropics (20°S-35°S & 20°N-35°N)
  - The regions of interest include tropics (20°S-20°N), subtropics (20°N-40°N & 20°S-40°S), mid-high latitudes (40°N-65°N & 40°S-65°S), North America (30°-60°N & 80°-120°W), and Russia (50°-65°N & 40°-140°E)

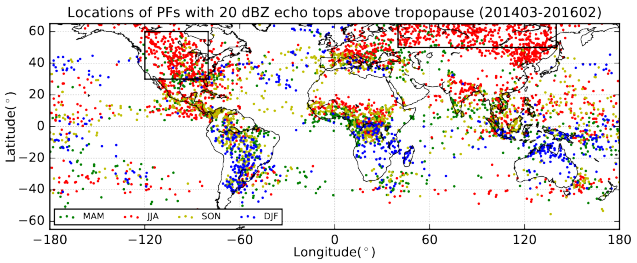

Figure 1. Locations of overshooting convection reaching tropopause in different seasons. The overshooting systems in each season are shown in symbols of different colors. The black boxes show regions of North America and Russia used in this study.

Maximum reflectivity profiles in OPFs over different regions

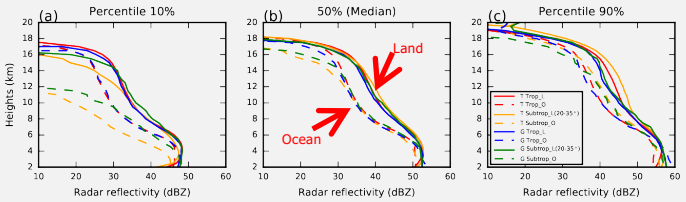

Figure 2. TRMM vs. GPM maximum Ku radar reflectivity in OPFs reaching tropopause in different regions. (a) 10% percentile, (b) Median, (c) 90% percentile. The subtropics is 20°N-35°N & 20°S-35°S here to be comparable to TRMM. Note that though the profiles from TRMM and GPM are general consistent, differences are also obvious, including a higher reflectivity at levels below 4 km and a slight lower reflectivity at upper levels by GPM.

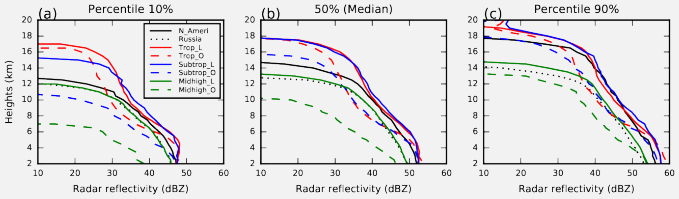

Figure 3. Maximum Ku radar reflectivity of GPM OPFs reaching tropopause in different regions. (a) 10% percentile, (b) Median, (c) 90% percentile.

Passive microwave brightness temperatures in OPFs over different regions

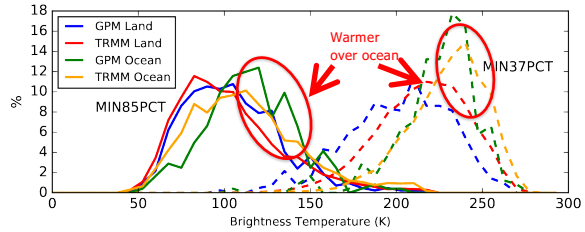

Figure 4. TRMM vs. GPM histograms of minimum 85 (89 for GMI) and 37 GHz polarization corrected brightness temperatures in OPFs over tropics (20°N-20°S). The OPFs are relatively weaker over ocean as indicated by warmer PCTs. Note that at 85 GHz, GMI shows colder PCTs than TMI, however, at 37 GHz, this is reversed. This might be caused by smaller FOV by GMI than TMI at 37 GHz. The different GMI and TRMM PCTs also imply that slightly different groups of storms being sampled by GMI and TMI. This might be caused by the limited samples from GPM and needs further validation in the future.

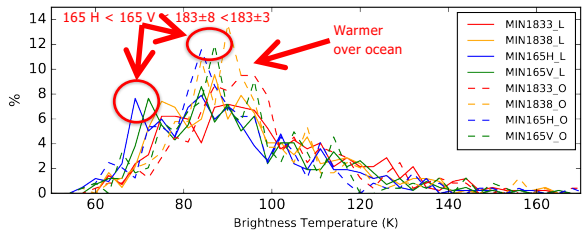

Figure 5. Histograms of minimum brightness temperature at high frequency channels in OPFs over tropics (20°N-20°S). The differences among these channels could be useful in understanding the properties of deep convection.

Size of OPFs in different regions

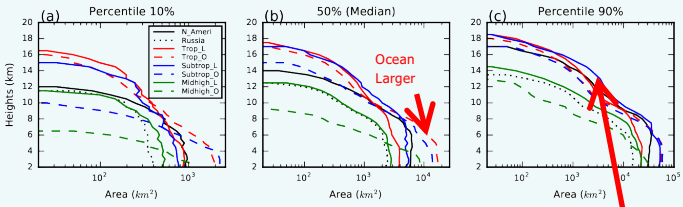

Figure 6. 20 dBZ area profiles of GPM OPFs, (a) 10% percentile, (b) Median, (c) 90% percentile.

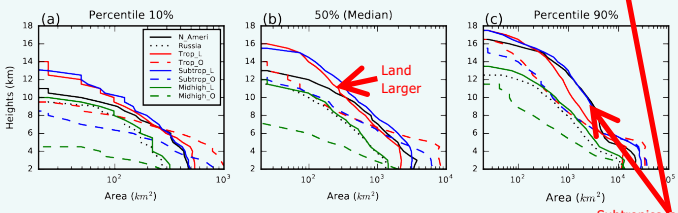

Figure 7. 30 dBZ area profiles of GPM OPFs, (a) 10% percentile, (b) Median, (c) 90% percentile

Subtropics larger than tropics

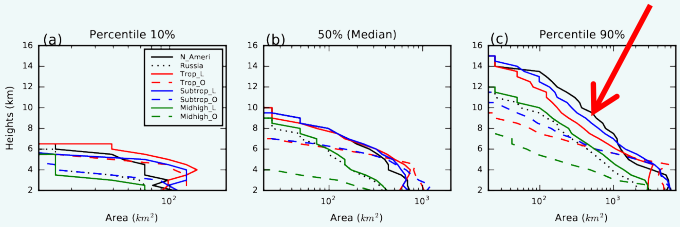

Figure 8. 40 dBZ area profiles of GPM OPFs, (a) 10% percentile, (b) Median, (c) 90% percentile

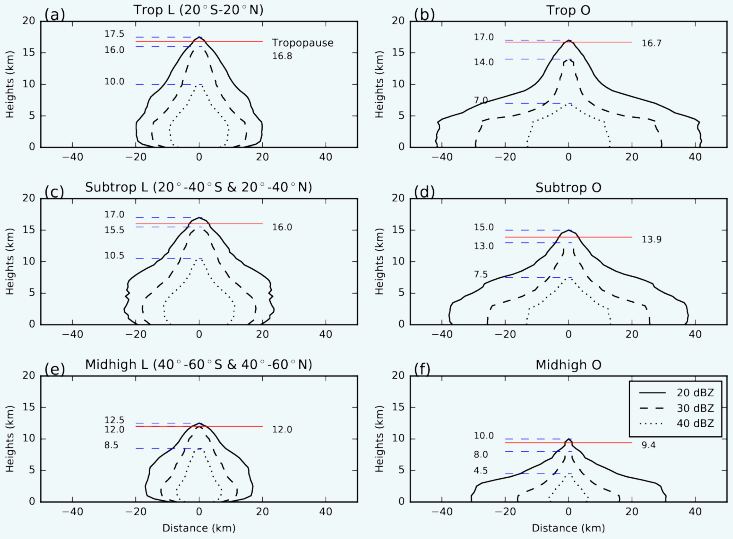

Figure 9. Median length scale of OPFs over different regions. (a) Tropical land, (b) Tropical ocean, (c) Subtropical land, (d) Subtropical ocean, (e) Mid-high latitudes land, (f) Mid-high latitudes ocean. The OPFs length scale L is calculated by $L = \pm(A/\pi)^{0.5}$, where A is area of 20, 30, 40 dBZ at different altitudes. It represents radius at each altitude assuming the conical shape of storm. The dash blue lines are the maximum heights of 20, 30, 40 dBZ in OPFs; the solid red line is the median of lapse rate tropopause heights.

- OPFs are bigger at lower levels over ocean, but bigger at upper levels over land
- OPFs reach higher over land than over ocean

Summary:

- Both TRMM and GPM show that overshooting storms are stronger over land than over ocean with higher reflectivity values at upper levels. Some subtropical storms are stronger than those in the tropics.
- GPM OPFs have maximum reflectivity profiles similar to TRMM OPFs over the tropics.
- Oceanic systems are bigger than land systems at low levels, but smaller than land systems at upper levels.
- There are still some questions to be answered by further study, including that GMI 89 GHz is warmer than TMI 85 GHz, but colder than TMI at 37 GHz in OPFs (this is the same for PFs reach 14 km); TRMM and GPM OPFs have some slight reverse differences in the vertical radar reflectivities at upper and lower levels.

Acknowledgements:

This research was supported by NASA Precipitation Measurement Mission grants NNX16AD76G under the direction of Dr. Ramesh Kakar. Thanks to Erich Stocker and the Precipitation Processing System (PPS) team at NASA Goddard Space Flight Center, Greenbelt, MD, for data processing assistance.